NOTHING IS SIMPLE

On a Word Scientists Forgot to Question

By Richard Preschel © 2026

ABSTRACT

The word "complexity" is ubiquitous in science, mathematics, and popular scientific discourse. It is deployed with confidence, as though its meaning were settled and its opposite — simplicity — were a genuine feature of the natural world. This article argues that simplicity does not exist outside of our minds and our cultural practices. Every object examined with sufficient care opens into further depth. Complexity, properly understood, is not a property of things but a relation between a thing and the models we bring to it — a measure of the distance between what is there and what our cognitive apparatus, shaped by evolution for purposes quite other than scientific understanding, can comfortably represent. The article examines what scientists and mathematicians are actually doing when they use the word "complexity," critiques the popular claim that the human brain is the most complex object in the known universe, and proposes that the question we have forgotten to ask — what is simple? — is more illuminating than the question we never stop asking about complexity.

Keywords: complexity, simplicity, philosophy of science, Wittgenstein, language games, immune system, brain, cognitive limits, evolution, parsimony.

The Unexamined Word

There is a word that appears on almost every page of popular science, in the titles of academic papers, in the lectures of physicists, biologists, and computer scientists, and in the pronouncements of science communicators addressing general audiences. The word is *complex*, or its noun *complexity*. It is used with an air of precision it does not possess, and it smuggles in an assumption that has never been examined: that its opposite — *simple*, *simplicity* — corresponds to something real.

The question nobody asks is the one that should be asked first: does simplicity exist? Not in our models, not in our descriptions, not in the convenient fictions we use to make mathematics tractable — but in the world itself, independent of any observer?

The answer, when pursued honestly, appears to be no. And the implications of that answer are considerable — for science, for philosophy, and for our understanding of what we are doing when we claim to understand anything at all.

What Wittgenstein Would Have Asked

Ludwig Wittgenstein, in the *Blue Book* (1933–34), observed: "a noun makes us search for a thing that corresponds to it."[1] This is one of the most condensed and powerful diagnoses of philosophical confusion ever written. We have a word; we assume there must be an object it names; we then spend our time searching for the object rather than questioning the assumption.

Complexity and *simplicity* are precisely such nouns. They make us search for things — for objects in the world that are genuinely, intrinsically simple or complex — when we should be asking what we are *doing* when we use these words. This is the Wittgensteinian question: not what does the word mean, but what are people doing when they use it? What language game are they playing, in what context, for what purpose, with what consequences?

When scientists and mathematicians use "complexity," the honest answer is that they are doing several quite different things that share a family resemblance but no single common referent. In algorithmic information theory, complexity is the length of the shortest program that can generate a given output — Kolmogorov complexity. In computational complexity theory, it measures how the resources required to solve a problem scale with the size of the input — the domain of P versus NP. In dynamical systems theory, it points to sensitive dependence on initial conditions. In network theory, it describes properties of highly connected graphs with emergent behaviors. In biology and the natural sciences, it gestures at the number of interacting components, the non-linearity of their interactions, the emergence of properties not predictable from the parts alone.

These are not the same thing. A system that scores high on one measure may score low on another. And in popular scientific discourse, complexity often functions as something else entirely — a ceremonial marker that we are in the presence of something impressive, something that exceeds our current understanding, something before which we should be appropriately humbled.

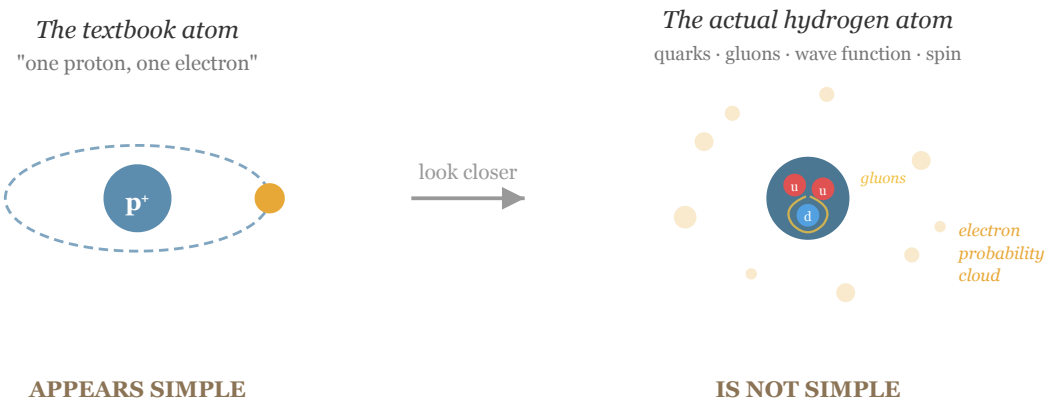
In this last use, complexity is less a description than an attitude. And simplicity is its shadow — the baseline we assume exists, against which complexity is measured, but which we never subject to the same scrutiny.

The Hydrogen Atom

Consider the hydrogen atom — the standard example of simplicity in all of physics. One proton, one electron. The first element. The most abundant substance in the universe. If anything deserves to be called simple, it should be hydrogen.

But the electron does not orbit the proton like a planet orbiting a sun. That picture, which we all encountered in school, is wrong. The electron exists as a probability cloud described by a wave function, governed by quantum mechanics, with properties like spin that have no classical analogue whatsoever. The proton itself is not simple: it is composed of three quarks bound

together by gluons through the strong nuclear force, described by quantum chromodynamics — one of the most mathematically formidable theories in all of physics. The quarks are held in a state of permanent confinement that physicists can describe mathematically but cannot fully explain conceptually.



The hydrogen atom: conventionally the simplest object in physics. Left: the textbook picture. Right: what is actually there — three quarks bound by gluons inside a proton, and an electron existing as a probability cloud. Simplicity was in the model, not the atom.

The hydrogen atom is only simple relative to a uranium atom, or a protein, or a brain. It is simple the way a sentence is simple relative to a novel — the comparison is meaningful, but it does not make the sentence actually simple when examined closely enough. Simplicity is always comparative, always relative to a level of resolution, always a feature of our description rather than of the thing described.

The universe does not know it is supposed to be simple at this particular scale.

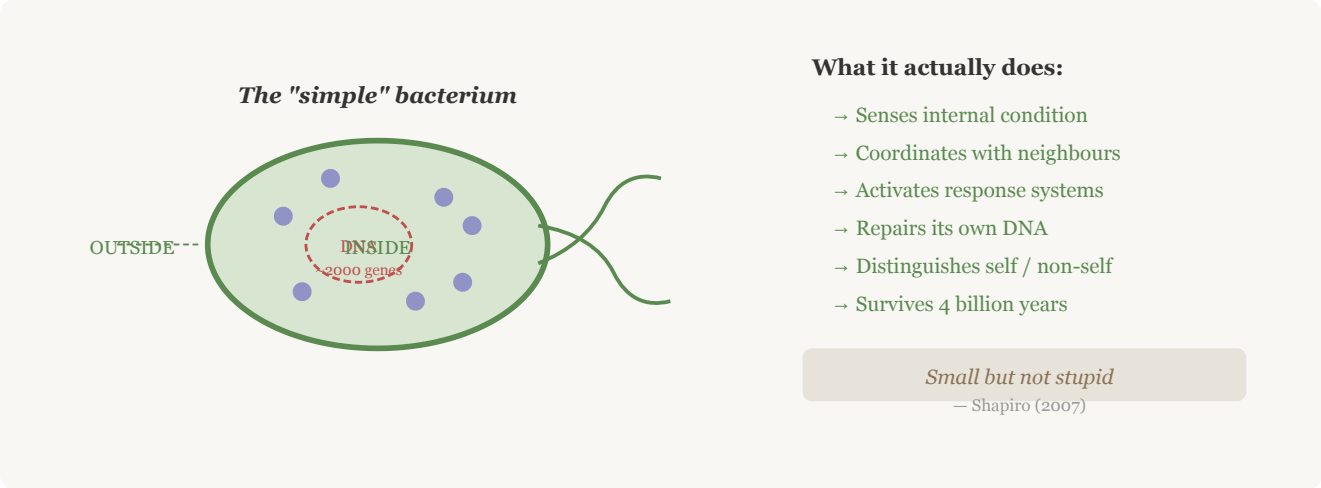
The Bacterium That Is Small But Not Stupid

If the hydrogen atom resists simplicity at the physical level, living organisms resist it even more dramatically — including those we have long assigned to the bottom of an implicit hierarchy.

The microbiologist James Shapiro has argued, with supporting evidence, that bacteria are "small but not stupid."[2] The simplest bacteria have a genome of approximately 2,000 genes — roughly ten percent of the size of the human genome. They sense their internal condition, coordinate with neighboring organisms through chemical signaling, and routinely activate elaborate response systems in reaction to ongoing challenges. They engage in something that resembles collective decision-making. They have been on Earth for approximately four billion years, have survived every mass extinction, and show every sign of continuing to thrive long after we are gone.

The biochemists Rainer Pascal and Addy Pross have argued that life's mental capability — in a minimal but genuine sense — is already apparent at this most elementary biological level.[3] The membrane that separates inside from outside, that regulates exchange with the environment, that maintains the distinction between self and world — this is not a simple structure performing a simple function. It is the physical basis of the most primitive awareness, the origin of what will eventually, after billions of years of elaboration, become human consciousness.

In this light, the assignment of "simplicity" to bacteria is not a scientific finding. It is a cultural prejudice — the product of our tendency to rank organisms by proximity to ourselves, and to call everything far from us simple because it is far from us.



A bacterium — conventionally assigned to the "simple" end of the biological hierarchy. Its genome of ~2,000 genes encodes capacities of remarkable sophistication. Simplicity was in our attention, not in the organism.

What Michio Kaku Gets Wrong

The physicist Michio Kaku is among the most visible science communicators of our era, and he has stated, with characteristic confidence, that the human brain is the most complex object in the known universe. This claim has been repeated so often, in so many popular books and television programs, that it has acquired the status of a settled fact. It is not.

The argument for the brain's supreme complexity typically rests on neuron count — approximately 86 billion — and synapse count — approximately 100 trillion connections. These are genuinely large numbers. But large numbers alone do not establish supremacy of complexity, particularly when the comparison is being made selectively.

Immunologists — who live daily with the operational complexity of what they study, who watch their models fail repeatedly against the system they are trying to map — have argued, with considerable force, that the human immune system is at least as complex as the human brain, and by certain measures more so.

Consider what the immune system must do. It must distinguish self from non-self across an essentially infinite variety of potential threats — bacteria, viruses, fungi, parasites, prions, cancer cells — most of which it has never encountered before and which are themselves evolving continuously to evade it. It must accomplish this without a central processor, without anything analogous to a command center, purely through distributed molecular recognition and signaling. The diversity of the adaptive immune system alone is staggering: the number of distinct antibodies a human immune system can potentially generate is estimated at something in the order of 10^{18} — a quintillion distinct molecular recognitions, produced by a combinatorial process of gene recombination that is itself a form of somatic evolution occurring inside the body in real time, throughout life.

Unlike the brain, which operates at one timescale and in one body, the immune system operates simultaneously across evolutionary time — through the arms race with pathogens — across developmental time — through maturation and memory — and across real time — through immediate response. It has memory, learns from experience, distinguishes ally from enemy,

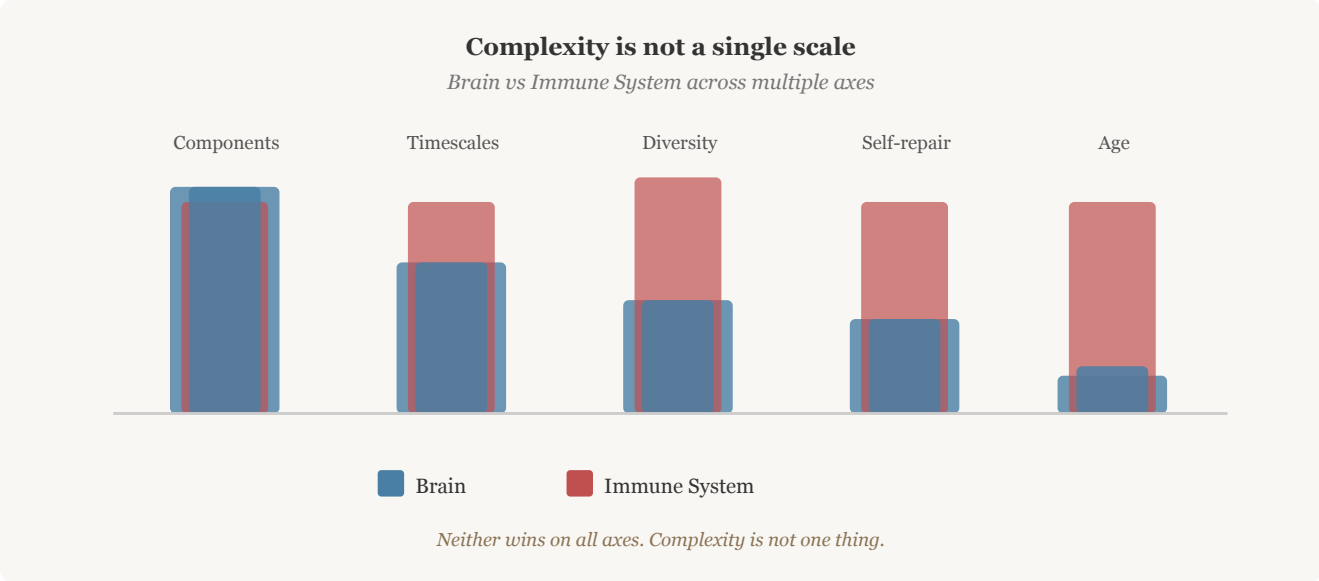
tolerates beneficial symbionts while attacking pathogens, and occasionally makes catastrophic errors of self-recognition that produce autoimmune disease — errors structurally analogous to the brain's psychoses.

Furthermore, Kaku's claim is implicitly and unjustifiably anthropocentric. The immune system is not a specifically human organ. Every vertebrate has one. Orcas and dolphins, whose brains rival or exceed ours in certain complexity measures, have immune systems of comparable intricacy. Sharks — cartilaginous fish, not bony vertebrates — have possessed a fully developed adaptive immune system for 450 million years, and have developed unique single-domain antibodies called IgNAR that are chemically more stable and functionally more versatile than conventional antibodies in certain respects. They have not changed substantially in all that time. If persistence is a criterion of adaptive success, the shark immune system has demonstrated a competence our own immune system, a comparative newcomer, has not yet had time to prove.

Octopuses complicate the picture further. They are invertebrates, mollusks, without an adaptive immune system in the vertebrate sense — no antibodies, no T cells, no immunological memory in the classical form. Yet they survive and thrive in microbiologically rich environments, are resistant to infection, and possess what appears to be a radically different solution to the problem of biological flexibility: they edit their own RNA at extraordinarily high rates, recoding the proteins their cells produce in response to environmental conditions. This is not a simplified version of what vertebrates do. It is something else entirely — a different axis of complexity, incommensurable with ours rather than inferior to it.

Which brings us to the deeper problem with Kaku's claim: it assumes that complexity is a single scale on which objects can be ranked. It is not. The brain and the immune system are solving different problems through different mechanisms at different scales. To declare one more complex than the other is to pretend that a single ruler can measure things that require different instruments.

The brain is extraordinary. But it did not corner the market on complexity. The universe was not waiting for a brain to arrive before it could produce something genuinely intricate.



Comparing the brain and the immune system across multiple dimensions of complexity. There is no single scale on which one can be declared the winner. Each system is solving different problems by different means — and comparison between them is less a scientific finding than a choice of metric.

What Bertrand Russell Knew in 1921

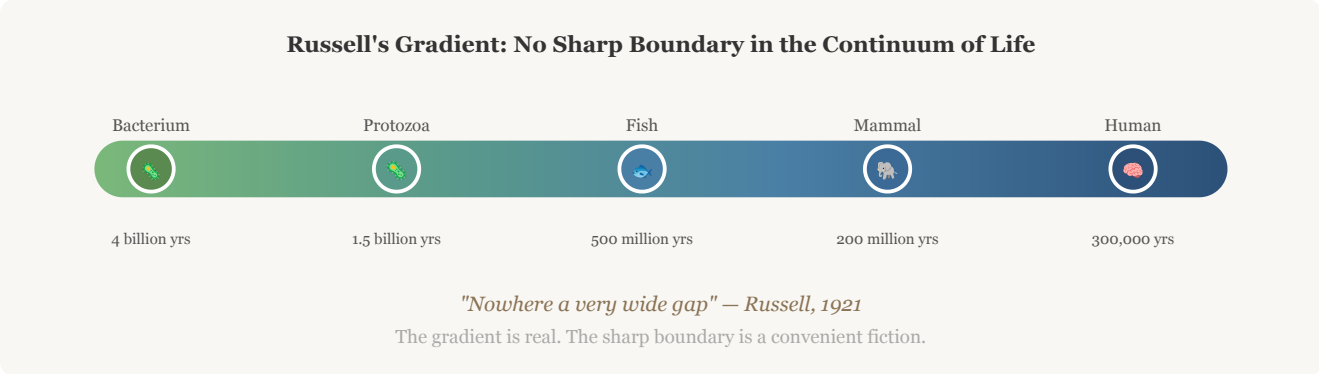
The philosopher Bertrand Russell, writing in *The Analysis of Mind* in 1921 — 105 years ago, without molecular biology, without knowledge of DNA, without the tools of modern immunology — drew the following inference from behavioral and structural observation alone:

> *"... from the protozoa to man there is nowhere a very wide gap either in structure or in behaviour. From this fact it is a highly probable inference that there is also nowhere a very wide mental gap."*
>
> — Bertrand Russell, *The Analysis of Mind* (1921), p. 41

Russell was refusing to draw an arbitrary line across the continuum of life and declare everything below it simple, mechanical, and dark. He was doing what good philosophers do: following an argument wherever it leads, without flinching at the conclusion because it is uncomfortable.

The subsequent century of biology has only strengthened his case. The tools have changed — we now have molecular biology, genomics, systems biology, and evolutionary biochemistry — but the conclusion is the same. There is no sharp boundary between the simple and the complex in

living systems. There is a gradient, ancient and continuous, from the proton gradient in the mitochondria of a bacterium to the neural symphony of a human brain. The gradient is real. The sharp boundary is a fiction we impose because our cognitive apparatus, evolved for other purposes, finds gradients difficult and boundaries comfortable.



Russell's argument visualised: the continuum of life runs without sharp discontinuity from bacterium to human. The assignment of "simplicity" to one end and "complexity" to the other reflects the observer's position on the gradient, not a property of the gradient itself.

Complexity as a Report on Our Models

There is one use of "complexity" that is more honest than the others, and it comes, characteristically, not from popular science but from researchers in the field. When an immunologist says the immune system is more complex than the brain, they are not primarily making a territorial claim in a prestige competition, though that dimension doubtless exists. They are reporting from the field. They are saying: we have been trying to understand this system rigorously for over a century, with increasingly powerful tools, and it keeps being more than our best model of it. Every time we think we have a clean conceptual framework, the system produces phenomena that don't fit and require the framework to be rebuilt.

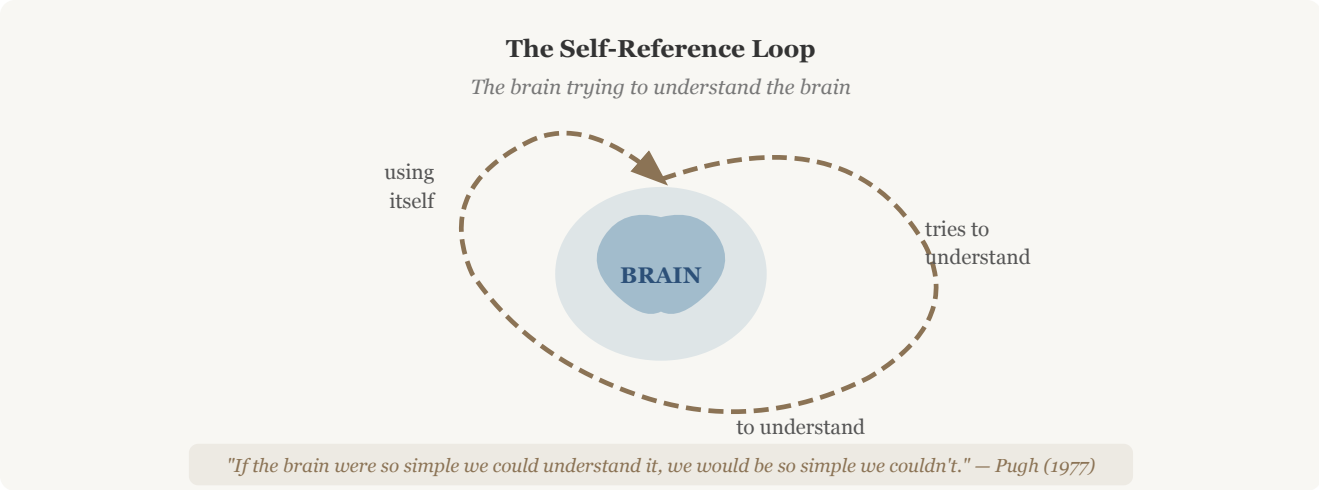
This is perhaps the most defensible scientific meaning of the word complexity: not a property of the world, but a report on the ongoing inadequacy of our models. Not "this thing is complex" but "this thing consistently exceeds our attempts to capture it."

On this reading, complexity is always relational. It describes the distance between the thing and the description. When a physicist calls the hydrogen atom simple, they are saying: my current model of hydrogen, at this level of resolution, fits in my head without strain. That is information about the physicist and the model, not about the hydrogen atom. The hydrogen atom, examined at the level of quantum chromodynamics, is anything but simple.

The Emerson M. Pugh aphorism, quoted by Daniel Dennett, captures this self-referential trap with elegant economy:

> *"If the brain were so simple we could understand it, we would be so simple we couldn't."*
>
> — Emerson M. Pugh, *The Biological Origin of Human Values* (1977), quoted in Dennett (2017), p. 371

The organ trying to understand itself is the same organ whose complexity prevents the understanding. The tool and the object of study are identical. No escape from this loop is currently available.


The Self-Reference Loop
The brain trying to understand the brain
using itself
BRAIN
tries to understand
to understand
"If the brain were so simple we could understand it, we would be so simple we couldn't." — Pugh (1977)

Pugh's paradox illustrated: the instrument of understanding and the object of understanding are identical. Any brain capable of fully grasping itself would need to be at least as complex as itself — which reproduces the problem rather than solving it.

The Hidden Ontological Commitment

Every time a scientist uses the word "complexity" without qualification, they are making a hidden ontological commitment: that simplicity exists as the baseline against which complexity is measured. This commitment has never been justified. It has simply been assumed.

The assumption is understandable. Our cognitive apparatus — shaped by natural selection for hunting, for social navigation, for predator detection and mate assessment, not for the understanding of quantum fields or immune system dynamics — finds it much easier to work with simplified models than with the full depth of what is there. We call things simple when our models of them are economical. We then mistake the economy of the model for a property of the thing.

This is the same error that Wittgenstein diagnosed throughout his later work: mistaking features of our representations for features of the world. The map is not the territory. The simple model is not evidence that the territory is simple.

B.F. Skinner, coming from a completely different tradition, made a related point about the vocabulary of psychology. Mental terms like "belief," "desire," "intention," and "intelligence" are not descriptions of internal objects. They are descriptions of behavioral patterns, of relations between organisms and their environments, that our language has reified into things. Once reified, we spend our time searching for the things — the beliefs, the desires, the intelligence — inside the brain, as though the nouns were pointing to objects rather than to patterns.[4]

"Complexity" and "simplicity" have undergone the same reification. We treat them as properties that objects possess — the way a ball possesses redness — when they are relations: between an object and a model, between a system and the tools we have available to describe it, between what is there and what we are currently capable of representing.

Evolution Is Cleverer Than You Are

There is a principle known as Orgel's Second Rule, named after the chemist Leslie Orgel: evolution is cleverer than you are. It was adopted and popularized by Daniel Dennett as a standing reminder to biologists not to assume that because they cannot imagine how natural selection could have produced something, natural selection could not have produced it.

The principle has a corollary relevant to our question: if evolution is cleverer than we are, then the products of evolution are likely to be more complex than our models of them. The immune system did not evolve to be understood by immunologists. The brain did not evolve to understand itself. The bacterium did not evolve to be legible to microbiologists. These systems evolved to do what they do — survive, reproduce, adapt — and they have been doing it, in many cases, for billions of years, with a competence that consistently exceeds our descriptions.

When we call something simple, we are often confessing that we have stopped looking. The simplicity is in the arrest of attention, not in the thing.

Conclusion: The Question We Forgot to Ask

The question "what is complexity?" is asked constantly. The question "what is simplicity?" is almost never asked. That asymmetry is itself revealing. We treat complexity as the phenomenon requiring explanation and simplicity as the self-evident baseline. But the evidence — from quantum mechanics to immunology to evolutionary biochemistry — suggests that simplicity is everywhere the fiction and complexity everywhere the reality, to whatever depth we are willing to look.

Nothing in nature is simple. The hydrogen atom is not simple. The bacterium is not simple. The immune system is not simple. The brain is not simple — though neither is it, contra Kaku, uniquely or supremely complex in a way that places it categorically above everything else the universe has produced.

Simplicity exists in our models. It exists in our descriptions. It exists in the convenient fictions that make mathematics tractable and communication possible. But it does not exist in the world those models are trying to describe. Every time we call something simple, we are — knowingly or not — making a statement about the limits of our attention, the resolution of our instruments, and the carrying capacity of our cognitive apparatus. We are not making a statement about the thing.

Wittgenstein said: don't ask for the meaning, ask for the use. When scientists use "complexity," they are variously measuring, confessing ignorance, marking prestige boundaries, and performing humility before audiences. What they are never quite doing is accurately describing an intrinsic property of the world — because intrinsic properties of this kind, independent of any observer and any model, are precisely what physics, biology, and philosophy have spent a century teaching us to be deeply suspicious of.

The word "complexity" is not wrong. It is useful. But it earns its usefulness only when we remember what it is actually measuring: not the world, but the distance between the world and us.

That distance, in every direction we have looked, turns out to be very large indeed.

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[1] "... ein Substantiv läßt uns nach einem Ding suchen das ihm entspricht." Wittgenstein, *Blue Book*, German translation by Petra von Morstein (1958).

[2] Shapiro, J.A. (2007), op. cit.

[3] Pascal and Pross (2022, 2023), op. cit.

[4] Skinner, B.F. (1974), op. cit.